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# Reasonableness of proposed improvement of the Rio Grande for navigation downstream of Amistad Dam

Prepared for the Office of the Attorney General of Texas

In relation to *United States vs. Abbott* Case No. 1:23-CV-853-DAE

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June 14, 2024

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## Summary of Background and Qualifications

I have over 47 years' experience in water resources engineering. My education includes both a PhD in hydraulic engineering and an M.S. degree in water and environmental engineering. I have authored numerous technical reports and papers for conference proceedings and journals dealing with development and management of rivers for navigation. I have served as an instructor for short courses on design of streambank protection projects, geomorphic assessment of stream and river channels, stream restoration, sedimentation and erosion.

I was employed by the Nashville District of the Corps of Engineers between 1978 and 1980, working on design and construction of the Tennessee-Tombigbee Waterway and management of the Cumberland River. I conducted research on water quality and ecology of large rivers including shallow draft waterways, for the federal government between 1980 and 2012. From 1980 to 1990 I was employed by the U.S. Army Engineer Waterways Experiment Station, conducting and leading investigations of environmental aspects of various features of shallow draft navigation projects nationwide including dredging and dredged material disposal, river training structures, streambank protection, flood control levees, and meander bend cutoffs. I completed my doctoral dissertation at Colorado State University on sedimentation in cutoff meander bends along the Tennessee-Tombigbee Waterway. From 1990 until 2012 I conducted research at the National Sedimentation Laboratory of the USDA Agricultural Research Service, and much of my work dealt with topics intrinsic to river navigation engineering: river bank erosion and its control, the role of large wood and vegetation in rivers, and design of stable channels. Since 2012 I have served as a consulting engineer dealing with projects involving flooding, erosion, floodway and levee setback design, and reservoir management.

My resume is provided as Appendix A to this report.

## Summary of Opinions

In my opinion a project that would produce commercial navigation on the Rio Grande River at a cost less than benefits is not feasible. The waters of the Rio Grande, between river miles 610 and 0, would be depleted by any conceivable project to establish commercial navigation. There are only two general methods to create a navigable waterway: an open river or a canalized waterway. Either method would overtax the River's available water resources. I estimate that if the River were converted into an open waterway modified to the depth and width required for commercial vessels, the water releases needed to maintain navigable depths in the channel would deplete Amistad Reservoir in about 143 days. Similarly, creating a canal system on the Rio Grande would require high-rate water flows that the River only experiences during exceptional times to be sustained year round—an impossible feat.

Additionally, the benefits are improbable. Cost-benefit analysis for inland navigation projects has historically been unreliable, mainly due to the overestimation of projected benefits (National Academies 2004 and 2015)<sup>1</sup>. Several inland waterway projects have been deauthorized due to a lack of traffic<sup>2</sup>. In other cases, such as the Tennessee-Tombigbee Waterway, actual traffic has been a fraction of the pre-construction projections (Stine 1993).

My analysis rules out a commercial waterway. Development of a commercial navigation waterway would require either higher flows than available or dredging and construction of locks and dams along with removal

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<sup>1</sup> See also Army Corps employee receives whistleblower award, Government Executive, (March 7, 2001) <https://www.govexec.com/federal-news/2001/03/army-corps-employee-receives-whistleblower-award/8628/>

<sup>2</sup> Among these are the Cross Florida Barge Canal, the New Savannah Bluff Lock and Dam (NSBLD) project on the Savannah River, and the Pearl River Navigation Project in Mississippi and Louisiana.

of some existing infrastructure, addition or modification of bridges, and probably some river training and bank stabilization structures. Such a project is impractical.

## The feasibility of hydraulic improvements

Waterways suited to commercial navigation by shallow draft vessels may be developed in two ways: as open river or instead as canalized waterways. Open river waterways in the US are normally limited to large rivers such as the Mississippi and the Missouri. Canalized waterways are most common and can be created by a combination of dredging, building locks and dams and river training structures. Official guidance for layout and design of shallow draft waterways (i.e. waterways that are used for commercial barge traffic) is provided by the Corps of Engineers in Engineer Manual 1110-2-1611 (US Corps of Engineers 1983). Commercial traffic comprises one or more barges pushed by tow boats. These clusters of vessels are called tows.

Modern commercial shallow draft waterways are designed to have a minimum water depth of 9 ft (USACE 1980, p. 3-2), but deeper channels are desirable since less energy is required to move barges through deeper waters (USACE 1980, p. 3-2). Commercial waterways with shallower depths existed in the past, but I believe all of these have been deauthorized. National Academies (2015) provides a catalog of shallow draft waterways in the US. The contemporary minimum standard channel depth is 9-12 feet. Adopting this minimal number, I assume an authorized channel depth of 9 ft for future improvements.

Minimum waterway channel widths refer to the bottom width of the channel. Engineer Manual 1110-2-1611 (US Army Corps of Engineers 1980) provides guidelines for one-way and two-way traffic waterways. Widths must allow for space on the sides of the barges and between up-bound and down-bound tows on two-way waterways. Additional width is required in bends and in areas where barges are moored or grouped into tows (such as up- and downstream of locks). “Operating experience has indicated that the minimum clearance required for reasonably safe navigation in straight reaches should be at least 20 feet between tow and channel

limits for two-way traffic, 40 feet for one-way traffic, and at least 50 feet between tows when passing.”<sup>3</sup> Herein we assume a navigation channel width<sup>4</sup> of 250 ft based on reasoning presented by Taylor (2024).

## Open river waterways

Transforming the Rio Grande between river miles 610 and 0 into an open river passable by commercial barge traffic would severely strain the River’s existing water resources. In this section I calculate that creating the 9-foot deep, 250-foot wide channel needed for shallow draft navigation on the Rio Grande would empty Amistad Reservoir in 143 days.

In open river navigation, minimum flow depths limit the passage of water craft. The minimum or controlling depths tend to occur at high points of the streambed along the channel that are referred to as riffles in smaller streams and as thalweg crossings in larger rivers. Rapids also represent high points with minimum water depths. Very shallow depths corresponding to high points along the bed of the Rio Grande occur at numerous locations downstream from Amistad Dam.

For viable operation, a waterway must reliably provide water depths greater than or equal to the authorized depth across the full width and along the full length of the navigation channel. Isolated shallows may be deepened by dredging, but extensive dredging along the width and length of a relatively steep open river waterway will allow the water to flow faster and shallower. Thus, shallow sections of the Rio Grande become

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<sup>3</sup> Paragraph 4-5, p. 4-2, USACE (1980).

<sup>4</sup> Note that the water width would be at least somewhat wider since the navigation channel must be at least as deep as the authorized depth (assumed 9 ft) for the full authorized width. This width is quite conservative for a waterway channel with bends. Passage of tows through bends, especially when two-way traffic is involved, can require minimum channel widths of 300 ft to 600 ft (Petersen 1986).

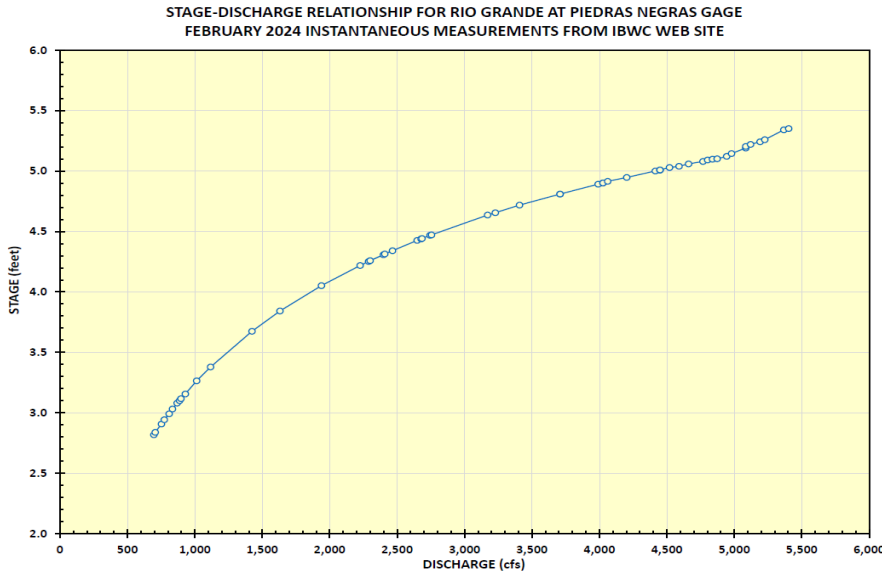
deep enough to allow commercial navigation only during high flows. Below we explore the frequency of flows required to produce navigable depths in a key reach of the Rio Grande.

The IBWC maintains a network of river gages that record measurements of water level and flow. Water levels are recorded at each gage as a ‘stage.’ Stage is the distance between the water level and a specific arbitrary base elevation for each gage, which is referred to as the gage datum. So, a gage reading of 10 ft at a certain gage means that the water level at the gage is 10 ft above the gage datum. The gage datum may be higher or lower than the riverbed. Water depth is the distance between the water level and the riverbed and varies continuously across the channel and up- and downstream. As an example, consider a situation where the gage reading is 10 ft and the water depth at a particular location is 5 ft. If the flow increases, the river rises. Suppose the river rises by 2 ft. Then the gage reading will be 12 ft and the water depth will be 7 ft.

Water flow (discharge) measurements are frequently made at the gage locations. These measurements represent the total flow of the river passing the gage location, in units such as cubic feet per second or cfs. A plot of the water flow measurements versus gage readings made at the exact same time is referred to as a stage-discharge curve. For the gage near Eagle Pass, for IWBC gage 08-4580.00, the stage-discharge curve shows that a stage of 3.3 ft is associated with a flow of about 1,000 cfs<sup>5</sup> (see **Figure 1**).

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<sup>5</sup> A gage reading or “stage” is the vertical distance between the water surface elevation and the elevation that corresponds to a gage reading of 0.0, which is also called the datum. The datum does not correspond to the elevation of the riverbed, so a gage reading of 3 ft does not imply a water depth of 3 ft.



**Figure 1. Stage discharge relation for Rio Grande at Eagle Pass based on flows occurring in February 2024 (Brandes 2024).**

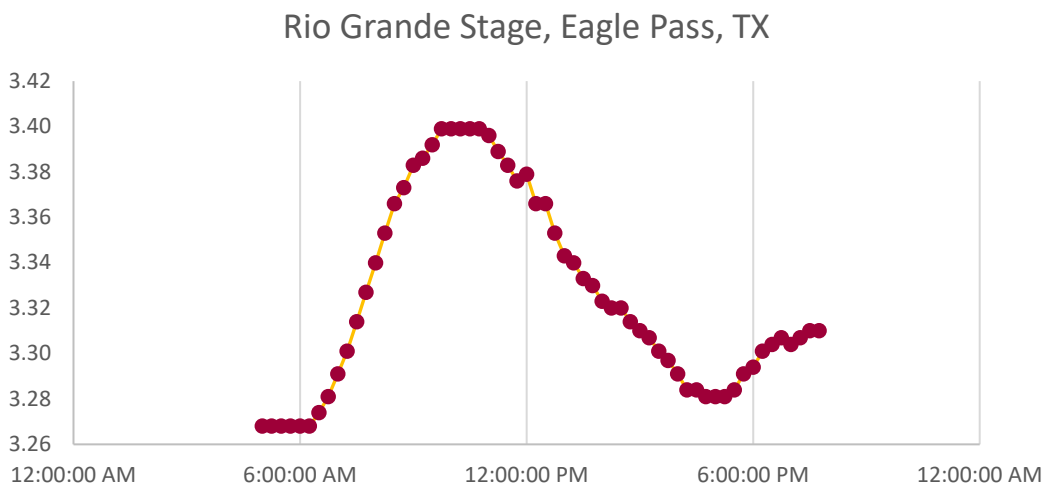
A stage of about 3.3 ft and a flow of about 1,000 cfs produces water depths that are less than 0.5 ft in the reach containing the buoys (see **Figure 2** below). Although shallow depths occur only in part of the cross section (for example, near one bank), the required width of a commercial navigation channel (250 ft) would require at least that much of the channel width to reliably provide depths equal to or greater than the minimum authorized depth. Cortez noted that a hydraulic model of the Eagle Pass reach of the Rio Grande prepared by the National Weather Service shows water depths as shallow as 3 ft under high (but not overbank) flows.<sup>6</sup> To produce 9 ft water depths extensive enough to support navigation in this reach, the river stage would have to increase at least 8.5 ft to an Eagle Pass gage height of  $3.3 + 8.5 = 11.8$  ft. Water depths would have to increase to a gage reading of  $3.3 + 11.5 = 14.8$  ft for a 12 ft channel.

<sup>6</sup> Cortez, Adrian, "Expert Report on Rio Grande Basin Operations," at p. 32.

These stages (greater than 6.0 ft) are not present on the rating curve in **Figure 1**, but stage data from the IBWC's Eagle Pass gage (using data collected in 15 minute increments between January 1, 2012 – May 16, 2024) indicates that stages of 11.8 ft were equaled or exceeded only 0.064% of the time and stages of 14.8 ft were equaled or exceeded only 0.026% of the time (**Table 1**).



*Migrants walk by a string of buoys placed on the water along the Rio Grande border with Mexico in Eagle Pass, Texas, on July 15, 2023, to prevent illegal immigration entry to the U.S. (Photo by SUZANNE CORDEIRO/AFP via Getty Images). From <https://thehill.com/regulation/court-battles/4156040-rio-grande-buoys-mostly-in-mexican-waters-survey-finds/>*



**Figure 2. Photo taken July 13, 2023 (top) and concurrent stage data from the gage at Eagle Pass, Texas (bottom) indicate water depths are less than about 0.5 ft in portions of the channel cross section in the**

reach containing the buoys when stages are between about 3.3 and 3.4 ft. Figure 1 above indicates that flows are between about 1,000 and 1,150 cfs for this range of stage.

**Table 1. Frequency of stage, ft at Rio Grande at Eagle Pass gage, 2012 – May 2024<sup>7</sup>**

Stage, ft	Frequency <sup>8</sup>	Cumulative Frequency	% of time	% of time greater than
2.50	402	402	0.1%	99.9%
2.75	5621	6023	1.4%	98.6%
3.00	71966	77989	18.1%	81.9%
4.00	283232	361221	83.9%	16.1%
5.00	28686	389907	90.6%	9.4%
6.00	15778	405685	94.2%	5.8%
7.00	19250	424935	98.7%	1.3%
8.00	4424	429359	99.7%	0.278%
9.00	371	429730	99.8%	0.192%
10.00	214	429944	99.9%	0.142%
11.80	336	430280	99.9%	0.064%
12.00	40	430320	99.9%	0.055%
14.80	123	430443	100.0%	0.026%
>14.80	113	430556	100.0%	0.000%

Another way to determine required flows to produce a given water depth is to assume uniform flow conditions at typical high points along the river bed. If water depths are required to equal or exceed a certain value for navigation, we can solve for the associated discharge using the Manning equation:

$$Q = \frac{1.486AR^{2/3}\sqrt{S}}{n}$$

in which

Q = discharge, cfs

<sup>7</sup> Computed from data downloaded from IWBC webpage for the Eagle Pass gage:

<https://waterdata.ibwc.gov/AQWebportal/Data/Location/Dashboard/37/Location/08458000/Interval/Latest>

<sup>8</sup>Stage readings are recorded at this gage every 15 minutes. “Frequency” refers to the number of stage readings between 2012 and 2024 that fell within the interval between the stage in the leftmost column of the given row and the preceding row.

1.486 = conversion factor for US units

A = cross section of flow

R = hydraulic radius, which is approximately equal to the depth for a wide cross section

S = water surface slope

n = Manning roughness coefficient, which ranges from 0.030 to 0.051 for the channel in this reach according to the FEMA flood insurance study.

If we assume that the water cross section may be approximated by a rectangle that is 300 ft wide and that the slope varies over a range of values determined by the model in Ancil Taylor's expert report<sup>9</sup>, we can solve for the discharge for a range of values of water depth (**Table 2**). Taylor's figures indicated that the slope in the Eagle Pass reach was about 4.30E-04, and **Table 2** indicates a flow equal to or greater than 10,285 cfs would be required at that slope to provide 9 ft of water depth and that 16,613 cfs would be required for 12 ft of depth. The flows in **Table 2** may be converted to acre-ft per year by multiplying by the number of seconds in a year and dividing by the number of square feet in an acre (**Table 3**).

**Table 2. Discharge values in cfs required to produce the given water depth in a rectangular cross section for the given slope with a Manning n value of 0.04 and a water width of 300 ft.**

Water depth, ft	Slope						
	3.00E-05	1.30E-04	2.30E-04	3.30E-04	4.30E-04	5.30E-04	1.00E-03
8	2,232	4,647	6,181	7,404	8,452	9,383	12,889
9	2,717	5,655	7,522	9,010	10,285	11,419	15,685
10	3,238	6,741	8,966	10,740	12,260	13,611	18,696
11	3,796	7,901	10,510	12,589	14,370	15,954	21,914
12	4,388	9,134	12,150	14,553	16,613	18,444	25,334

<sup>9</sup> Model described in expert report by Ancil Taylor. The modeled reach starts at Amistad Dam and extends 239 miles downstream to the headwaters of Falcon Reservoir and from Falcon Dam to the mouth of the Rio Grande. The reach containing Falcon Reservoir was not included as water surface slopes there are not representative of the rest of the system.

Analysis of mean daily discharges for the Rio Grande at the Eagle Pass, Texas gage for 2000-2018 by Brandes (2024) indicates that the flows in **Table 2** were equaled or exceeded only a small percentage of the time (**Table 4**).

**Table 3. Discharge values in acre-ft/yr corresponding to the rates in cfs listed in Table 2.**

Water depth, ft	Slope						
	<b>3.00E-05</b>	<b>1.30E-04</b>	<b>2.30E-04</b>	<b>3.30E-04</b>	<b>4.30E-04</b>	<b>5.30E-04</b>	<b>1.00E-03</b>
<b>8</b>	1.62E+06	3.37E+06	4.48E+06	5.36E+06	6.12E+06	6.80E+06	9.34E+06
<b>9</b>	1.97E+06	4.10E+06	5.45E+06	6.53E+06	7.45E+06	8.27E+06	1.14E+07
<b>10</b>	2.35E+06	4.88E+06	6.50E+06	7.78E+06	8.88E+06	9.86E+06	1.35E+07
<b>11</b>	2.75E+06	5.72E+06	7.61E+06	9.12E+06	1.04E+07	1.16E+07	1.59E+07
<b>12</b>	3.18E+06	6.62E+06	8.80E+06	1.05E+07	1.20E+07	1.34E+07	1.84E+07

**Table 4. Duration of Rio Grande flows listed in Table 2 based on 2000 – 2018 mean daily discharges.**

Water depth, ft	Slope						
	<b>3.00E-05</b>	<b>1.30E-04</b>	<b>2.30E-04</b>	<b>3.30E-04</b>	<b>4.30E-04</b>	<b>5.30E-04</b>	<b>1.00E-03</b>
<b>8</b>	25.0%	9.0%	6.0%	4.0%	3.5%	2.5%	1.2%
<b>9</b>	17.0%	7.0%	4.0%	2.5%	1.6%	1.4%	1.0%
<b>10</b>	14.0%	5.0%	2.5%	1.4%	1.4%	1.2%	0.8%
<b>11</b>	11.0%	4.0%	1.6%	1.4%	1.0%	1.0%	0.4%
<b>12</b>	10.0%	2.5%	1.4%	1.0%	1.0%	0.8%	0.4%

The significance of the values in **Tables 2** and **3** may be further explored by considering them in relation to the storage volume and annual releases from Amistad Dam. Amistad Reservoir has a conservation pool

storage capacity of about 3.2 million acre-feet<sup>10</sup> but median storage water volume from 1990 to 2023 was about 70% of capacity<sup>11</sup>, or 2.26 million acre ft. Mean annual outflow for the period 1969 to 2000 was about 1.68 million acre ft, or about 2,320 cfs (Miyamoto 2006). For the sake of argument, let us assume that all water uses downstream from Amistad except navigation are suspended. Comparing the average annual Amistad outflow (1.68 million acre ft) value with those in **Table 3** indicates that releasing flows from Amistad Dam adequate to support open river navigation in reaches with slopes comparable to that found in the Eagle Pass reach would require increasing releases by factors of 4 to 7. This water is not available in the watershed upstream from Amistad, so increasing releases to support navigation would deplete the storage in the reservoir. For just the 9 ft channel, the difference between current releases (1.68 million acre ft/yr) and those needed for navigation (7.45 million acre ft/yr, **Table 3**) would be a net demand of 5.77 million acre ft/yr on the reservoir storage. For purposes of rough assessment, we can convert this figure to a rate of 15,800 acre-ft/day. This would completely deplete the 2.26 million acre ft of storage<sup>12</sup> in Amistad Reservoir in 143 days.

## Locks and dams

Adequate depths may be maintained across a wider range of flows using a system of locks and dams. Ancil Taylor's expert report has provided a scheme showing that the Rio Grande from Amistad Dam to the mouth might be developed for navigation using a system of 45 locks and dams with an average lift of 22.3 ft. However, the water supply requirements of this canalized waterway render the scheme impractical. In years with high evaporation, water requirements would exceed supply. Even in years without extreme evaporation, the rough

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<sup>10</sup> Amistad International Reservoir, Texas Water Development Board, <https://www.twdb.texas.gov/surfacewater/rivers/reservoirs/amistad/index.asp>

<sup>11</sup> Amistad Reservoir, Water Data for Texas, <https://www.waterdatafortexas.org/reservoirs/individual/amistad>

<sup>12</sup> Ibid.

estimates above strongly suggest that other water uses would have to be eliminated or greatly reduced to support a canalized waterway system

### *Water requirements for lockages*

Operation of the locks will require water to be discharged downstream when lock chambers are evacuated. Although a system for pumping water back upstream after lock operation might be devised, herein I assume a traditional lock operation without a pump back system. If the lock chambers are 75 ft wide and 900 ft long to ensure compatibility with the Texas portion of the Gulf Intracoastal Waterway, a single lockage would require 22.3 ft x 75 ft x 900 ft, using the average lock lift for water depth. Using this logic, we may compute the water volume for a range of daily lockage values (**Table 5**). I assumed capacity for a maximum of 25 lockages per day based on typical transit times (45-90 minutes) for locks in US shallow draft commercial navigation waterways.

Projecting precise water requirements for lock operations would require a more detailed analysis that would consider traffic levels along the waterway, points of origin for commerce, loading and fleeting requirements, transit times, facilities needed for breaking up and reassembling tows above and below locks, and extreme low flows. The navigation system would have to be designed to reliably provide authorized channel water widths and depths during all but the most extreme low flow conditions. Projections of water requirements for testing the dam spillway gates and any unusual lock operations might also be considered.

Even in the context of this preliminary study, the simple calculations depicted in **Table 5** above suggest that water requirements for lock operations would be considerable given the annual flow in the Rio Grande. Myers and Nisbit (2022) provided data for 1960-2020 indicating that the annual flow at Laredo averaged 2.08 million acre ft and ranged from 0.89 to 4.37 million acre ft. Ten percent of the years had flows less than 1.15 million acre ft. **Table 5** indicates that if the waterway was experiencing enough traffic to require 25 lockages

per day, lock discharges would be equivalent to about 15% of the average total flow. In drier years flow would be much lower, but lockages would continue to demand the same amount of water. For the driest 10% of years, lockage would require more than 27% of the total flow in the river (**Table 5**)

number of lockages per day	ft <sup>3</sup> /day	acre- ft/day	cubic ft/sec	acre- ft/yr	% of mean annual flow at Laredo	% of 25%ile annual flow at Laredo	% of 10%ile annual flow at Laredo
1	1,505,250	34.6	17.4	12,622	0.6%	1.0%	1.1%
2	3,010,500	69.1	34.8	25,243	1.2%	1.9%	2.2%
3	4,515,750	103.7	52.3	37,865	1.8%	2.9%	3.3%
4	6,021,000	138.2	69.7	50,486	2.4%	3.9%	4.4%
5	7,526,250	172.8	87.1	63,108	3.0%	4.8%	5.5%
6	9,031,500	207.3	104.5	75,729	3.6%	5.8%	6.6%
7	10,536,750	241.9	122.0	88,351	4.3%	6.7%	7.7%
8	12,042,000	276.4	139.4	100,972	4.9%	7.7%	8.8%
9	13,547,250	311.0	156.8	113,594	5.5%	8.7%	9.9%
10	15,052,500	345.6	174.2	126,215	6.1%	9.6%	11.0%
11	16,557,750	380.1	191.6	138,837	6.7%	10.6%	12.0%
12	18,063,000	414.7	209.1	151,458	7.3%	11.6%	13.1%
13	19,568,250	449.2	226.5	164,080	7.9%	12.5%	14.2%
14	21,073,500	483.8	243.9	176,701	8.5%	13.5%	15.3%
15	22,578,750	518.3	261.3	189,323	9.1%	14.5%	16.4%
16	24,084,000	552.9	278.8	201,944	9.7%	15.4%	17.5%
17	25,589,250	587.4	296.2	214,566	10.3%	16.4%	18.6%
18	27,094,500	622.0	313.6	227,187	10.9%	17.4%	19.7%
19	28,599,750	656.6	331.0	239,809	11.6%	18.3%	20.8%
20	30,105,000	691.1	348.4	252,430	12.2%	19.3%	21.9%
21	31,610,250	725.7	365.9	265,052	12.8%	20.2%	23.0%
22	33,115,500	760.2	383.3	277,673	13.4%	21.2%	24.1%
23	34,620,750	794.8	400.7	290,295	14.0%	22.2%	25.2%
24	36,126,000	829.3	418.1	302,916	14.6%	23.1%	26.3%
25	37,631,250	863.9	435.5	315,538	15.2%	24.1%	27.4%

**Table 5. Water requirements for Rio Grande lock operations.**

*Water requirements for increased evaporation*

Transformation of the existing Rio Grande downstream from Amistad Dam into a series of lock pools would increase the water surface area subject to evaporation. Although evaporation varies with weather, a reasonable value for water budgeting would be 5 ft per year (Zhu et al. 2021). Constructing the series of 45 locks and dams as described by Ancil Taylor would certainly increase water surface area several-fold as the river is impounded and the water level raised to create lock pools. Lock pool elevations will be an average of 22.3 ft higher than the current normal flow water levels. Determining the impact of lock and dam construction on water surface area would require accurate locations for each dam and detailed topographic maps of the floodplain and channel bathymetry. However, it is my opinion that the new average water width would be 2 to 20 times larger than the current width. Additionally, I am assuming that the project would not change the average water surface area of Falcon Lake, consistent with assumptions made by Ancil Taylor's expert report.

Myers and Nisbit (2022) found that the mean annual outflow from Falcon Lake 1960-2020 was about 2.11 million acre ft. Further, on average, evaporation accounted for 14% (range = 6-47%) of total outflow, or 0.295 million acre ft per year. They also presented data showing that the average flow in the Rio Grande at Laredo is about 2.08 million acre ft per year and ranged from 0.89 to 4.37 million acre ft per year between 1960 and 2020, inclusive. During this time, annual flows were below 1.15 million acre ft for 10% of the time.

Using this factual background, we can roughly estimate the average annual evaporation from the existing Rio Grande, RM 0-610 exclusive of Falcon Lake, as the product of average water surface area times average evaporation depth, 5 ft. Water surface area is the product of the length of the channel (exclusive of Falcon Lake) times the average water surface width. Ancil Taylor computed the length of this channel to be 3,089,645 ft. Assuming an average existing water surface width of 300 ft, the average water surface area would be

$3,089,645 \times 300 = 926,900,000$  square ft or about 21,300 acres. Multiplying by 5 ft would give an annual evaporation of 0.107 million acre ft. Increasing this area by factors of 2 to 20 would produce losses from the river channel due to evaporation of about 0.213 to 2.13 million acre-ft per year. Combined with the average losses due to evaporation from Falcon Lake from above (0.295 million acre ft), the total evaporative loss would be between about 0.508 and 2.42 million acre ft per year (**Table 6**). The total evaporative loss would be equivalent to between 19% and 115% of the average annual outflow from Falcon Dam and from 44% to 210% of the 10th percentile flow at Laredo.

My preliminary study strongly suggests that canalizing the Rio Grande would be infeasible on water supply grounds. If we consider a scenario where the River has been outfitted with the system of locks and dams envisioned by Ancil Taylor's expert report with the maximum number of lockages and increased evaporation by a factor of five due to the lakes impounded by locks and dams. Lockage and evaporation would require 99% of the flow at Laredo for dry years (10 percentile total annual flow). Given time and economic resources, engineers and personnel from associated professions might be able to develop a shallow draft commercial waterway along the path of the Rio Grande between Amistad Dam and the mouth of the river at the Gulf of Mexico. However, the feasibility assessment of a lock and dam system along the Rio Grande must include detailed analysis of changes in water surface area, various weather scenarios including climate change, hydrologic extremes, spatial differences in evaporation and water availability and seasonal factors. Issues associated with climate change, erosion and sedimentation, channel stability, hydraulic structure design, water quality, ecology and social factors, among others, would demand intensive study and analysis. A canalized waterway project would require less water than an open river system, but the amount of water needed to address losses due to evaporation and lock operation would be prohibitive. In years with high evaporation,

water requirements would exceed supply. Even in years without extreme evaporation, the rough estimates above strongly suggest that other water uses would have to be eliminated or greatly reduced to support a canalized waterway system.

**Table 6. Estimated total annual evaporation from the Rio Grande when developed for shallow draft navigation between the mouth and Amistad Dam, RM 0-610.**

Surface area increase due to locks and dams (factor)	Total annual evaporation, acre ft/yr	% of mean annual Falcon outflow	% of 25%ile annual flow at Laredo	% of 10%ile annual flow at Laredo
1	4.01E+05	19.1%	30.6%	34.8%
2	5.07E+05	24.1%	38.8%	44.0%
3	6.14E+05	29.2%	46.9%	53.3%
4	7.20E+05	34.2%	55.0%	62.5%
5	8.27E+05	39.3%	63.1%	71.7%
6	9.33E+05	44.3%	71.3%	81.0%
7	1.04E+06	49.4%	79.4%	90.2%
8	1.15E+06	54.5%	87.5%	99.4%
9	1.25E+06	59.5%	95.7%	108.7%
10	1.36E+06	64.6%	103.8%	117.9%
11	1.46E+06	69.6%	111.9%	127.1%
12	1.57E+06	74.7%	120.0%	136.3%
13	1.68E+06	79.7%	128.2%	145.6%
14	1.78E+06	84.8%	136.3%	154.8%
15	1.89E+06	89.8%	144.4%	164.0%
16	2.00E+06	94.9%	152.5%	173.3%
17	2.10E+06	100.0%	160.7%	182.5%
18	2.21E+06	105.0%	168.8%	191.7%
19	2.32E+06	110.1%	176.9%	201.0%
20	2.42E+06	115.1%	185.1%	210.2%

## Expert opinions by others

### Summary of opinions concerning US experts

I have been asked to render opinions on the qualifications and testimony of Mr. Adrian Cortez, Mr. Timothy MacAlister and Captain John Timmel, experts serving the United States in this case. Specifically, I have the following opinions concerning their qualifications and testimony:

Cortez, MacAllister, and Timmel competently serve in their respective professions, but they are not hydraulic engineers and they do not possess expertise in river engineering or waterway design.

Cortez suggested that navigation could be enhanced by increasing water releases from Amistad Dam. If the USA penstocks released a constant 3,400 cfs it is not clear to me by how much downstream flows would increase since I am not sure what the discharge from the Mexican penstocks would be. Further, I am not sure how much diversion would be permitted downstream of Amistad. However, increasing flows by 3,400 cfs at Eagle Pass would increase stages by about 2.5 ft, less than the approximately 8.5 ft needed for safe navigation. Without locks and dams and dredging, a flow of about 10,000 cfs is needed in the Eagle Pass reach to create 9 ft channel depths. More flow would be needed in reaches with more gradual slope. Thus, even a total flow from Amistad of 8,400 cfs and elimination of all diversions between Amistad and Eagle Pass would not be adequate to produce 9 ft depths. Therefore, a system of locks and dams with dredging as described by Taylor (2024) would be required to provide reliable commercial navigation. The preliminary analysis provided by Taylor indicates that such a project would be economically infeasible. Political and environmental considerations would tend to make the feasibility of such a project even less likely.

MacAllister gives no support to the idea that the reach in question supports interstate or international commerce. No support is given to the idea that the reach could be made navigable by larger craft by engineering

modifications. "Reasonable improvements" are cataloged for improving navigability, but these seem to apply only to small craft used in recreation or law enforcement. His proposal for improvements to navigable capacity are unspecified amounts of dredging, bank stabilization, debris removal and modifications to existing infrastructure. However, a very simple hydraulic analysis of flows in a reach with slope similar to that at Eagle Pass indicates that a flow of about 10,000 cfs would be required to provide navigable depths in a channel of minimal width for commercial tows (300 ft). Dredging, weir and debris removal, removal of the Maverick Dam and bank stabilization would all be required but increasing flows from their current level up to a minimum of about 10,000 cfs would be needed to reliable open river navigation.

Timmel suggests that the development of the ~4-mile long channel on the Alafia River, a tributary of Tampa Bay, Florida is a good example of how the Rio Grande might be developed as a commercial waterway. This channel is relatively short and flat (no steep slope) whereas the Rio Grande is 610 miles long and has 915 ft of fall. Timmel does not comment on the information, data, modeling and studies needed to determine the amount of dredging required to straighten and deepen the Rio Grande as was done on the Alafia. He does not explain how the steeper slope of the Rio Grande would be handled, or how much additional water would be required to provide navigable depths in the deeper, wider, straighter dredged channel. Without such information, an estimate of project costs cannot be generated, and it cannot be determined if the projected commercial benefit of the improvements would exceed the costs of making the improvement.

All of the US experts' proposals for improvements to the Rio Grande were vague and lacking the detail that would be required for a bona fide engineering project. Actual planning and design of a Rio Grande navigation system for the reach between Amistad Dam and the river mouth would require a spectrum of studies, starting with ecological and social aspects of the system and extending to cultural resources,

hydrology, hydraulics, geology and river geomorphology. Geotechnical analyses would be required to assess materials to be dredged or excavated, to locate construction materials, and to devise schemes for dredged material disposal. Logistics would need to be considered since commerce occurs on networks, so the waterway would need to link nodes in the existing global network. Data sets including climate, hydrology, digital elevation models, bathymetry, biological and water quality data and many others would be needed. Models would include watershed hydrology, hydrodynamic models of the existing and proposed waterway, sediment transport and channel morphodynamics models and models of selected locks and dams would be needed.

## Cortez opinion

### Qualifications

Mr. Adrian D. Cortez is employed by the International Boundary and Water Commission and is an expert on the administration of the agreements allocating waters of the Rio Grande among its users, particularly international treaties and agreements between the United States and Mexico. He is knowledgeable about the characteristics and operations of the impoundments and diversions along the Rio Grande and its major tributaries. His education is in civil engineering with post-graduate work in environmental engineering, focusing on water treatment.

Mr. Cortez is not a hydraulic engineer. He does not have experience or education in river engineering, movable bed hydraulics or sediment management. He does not have experience in design, construction, operation or maintenance of open-river or canalized shallow draft waterways that support commercial navigation. He does not claim expertise in design or operation of a system of locks and dams, dredging to

support commercial navigation, or large-scale dredged material disposal. As a result, I do not believe Mr. Cortez is qualified to opine about the feasibility of these or similar modifications of the Rio Grande.

### Hydraulic improvements

The Cortez report notes that under the current treaty, water uses are prioritized in the following order: domestic and municipal, agriculture, power generation, other industrial and navigation. The treaty would have to be modified to elevate navigation over the four higher priorities<sup>13</sup>. Furthermore, additional water allocations would be required for more extensive use of the reach for navigation, as navigation is currently limited to smaller (< 30 ft long) watercraft for recreation and law enforcement and is limited by the presence of "infrastructure like weirs and small diversion dams."<sup>14</sup> Further, the report notes that additional infrastructure may be required to allow passage.<sup>15</sup> I concur with this portion of Cortez's opinion. However, Cortez does not provide any details about how existing infrastructure would be modified so as not to limit navigation. He does not provide any information about the "additional infrastructure" required for navigation. Without such information, an estimate of project costs cannot be generated and it cannot be determined if the projected commercial benefit of the improvements would exceed the costs of making the improvement.

Cortez does not discuss how conflicts between navigation and other prioritized water uses could be resolved. Conflicts with power generation would occur unless navigation was fully prioritized over

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<sup>13</sup> Cortez Expert Report at 10.

<sup>14</sup> *Id.* at 4

<sup>15</sup> *Id.*

hydropower. Data available on the IBWC website<sup>16</sup> shows that there are strong pulses due to hydropower operations immediately downstream from Amistad Dam. For example, in a 24 hour period there can be five or more pulses that increase flow by a factor of ~25 over base flow levels. Conflicts with water supply would occur unless navigation was fully prioritized over water supply. Downstream from Amistad Dam, irrigation diversions include the Maverick Canal, as described by Cortez, which diverts up to 1,500 cfs and results in greatly reduced flow rates and depths over a reach of 35.8 river miles.

Although not discussed by Cortez, the additional infrastructure required to support commercial shallow draft navigation could be either that needed for an open river waterway or a canalized waterway. I provide very general assessments of the feasibility of each of these options above. Despite the preliminary nature of this study, the facts presented above regarding water requirements for Rio Grande navigation are entirely adequate to indicate the infeasibility of any such scheme.

## MacAllister opinion

### Qualifications

Mr. Timothy MacAllister is Chief of the Operations Division of the Fort Worth District of the U.S. Army Corps of Engineers. His education comprises a B.S. in Range Management, and he has extensive experience in managing lands and waters associated with Corps reservoir projects. He has overseen operations and management of reservoir features dealing with law enforcement, flood control, recreation, water supply and environmental stewardship missions.

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<sup>16</sup>Retrieved from  
<https://waterdata.ibwc.gov/AQWebportal/Data/DataSet/Chart/Location/08450900/DataSet/Discharge/Best%20Available/Interval/Latest>

However, Mr. MacAllister is not a hydraulic engineer. He does not have experience or education in river engineering, movable bed hydraulics or sediment management. He does not have experience in design, construction, operation or maintenance of open-river or canalized shallow draft waterways that support commercial navigation. He does not claim expertise in design or operation of a system of locks and dams, dredging to support commercial navigation, or large-scale dredged material disposal. I do not believe that Mr. MacAllister is qualified to opine about the feasibility of modifications to the Rio Grande for commercial navigation.

### Hydraulic improvements

In his report, MacAllister expresses the opinion that the reach of the Rio Grande in question is navigable by small watercraft (less than 26 ft long), although low and high flows present difficulties.<sup>17</sup> No support is given to the idea that the reach supports interstate or international commerce. No support is given to the idea that the reach could be made navigable by larger craft by engineering modifications. He lists a number of "reasonable improvements" he believes capable of improving navigability,<sup>18</sup> but these seem to apply only to small craft used in recreation or law enforcement. The reasonable improvements described by MacAllister include releases of water from upstream dams; removal of snags, vegetation and shoals; adding boat ramps and access points; and constructing bank stabilization measures. Dredging is also mentioned as a form of improvement. Economics, commerce, and official authorization of water releases for navigation are not discussed. Without such information, an estimate of project costs cannot be generated and it cannot be

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<sup>17</sup> MacAllister Supplemental Expert Report at 3-4.

<sup>18</sup> *Id.* at 6-10.

determined if the projected benefits of the improvements would exceed the costs of making the improvement. Each of the “reasonable improvements” listed by MacAllister are discussed below.

#### *Timing water releases*

In light of the discussion above about the additional water requirements associated with developing the Rio Grande for commercial navigation, adjustments to the timing of water releases from Amistad Dam would not itself increase the total flow of water. Although modification of reservoir operating rules to adjust release timing would be an important part of prioritizing navigation over other water uses, timing adjustments alone cannot increase the total flow in the system, as would be required to make navigation feasible. Additionally, the examples MacAllister relies on are Corps of Engineer reservoirs that are not tributary to the Rio Grande.

#### *Clearing/dredging of shoals*

Construction of a viable waterway on the Rio Grande would require much more dredging than the limited shoaling locations MacAllister discusses. Development of a canalized waterway often requires dredging in the regions just downstream of a lock and dam to provide navigable depths in the shallower portions of the backwater created by the next downstream dam. However, management of either an open river or canalized shallow draft waterway would require active sediment management, including dredging locations prone to shoaling. In some cases, river training structures might be required to prevent shoaling by constricting the low water channel. Although maintenance dredging might be a major component of waterway maintenance cost, projecting maintenance dredging requirements is far beyond the scope of this report. A study of the watershed sediment sources and river geomorphology would be foundational. Sediment transport modeling including development of hydrodynamic models of the waterway and computation of sediment inflows along the navigation channel would be required to assess dredge volumes and frequency. These models would require

extensive field data on bed sediment size gradations and existing sediment loads and concentrations. Neither MacAllister nor any of the US's other experts have offered any of this analysis.

#### *Removal of snags and drift buildup*

Clearing large wood accumulations from the navigation channel is usually a required part of waterway operation and maintenance, but the amount of effort and funding required is a function of wood supply and channel width and depth. Dams usually accumulate floating wood upstream of their gates and the wood must be flushed downstream by gate opening or removed from the impoundment using cranes or other equipment. Removal of large wood accumulations from a river eliminates physical obstruction to passing vessels. It also reduces the resistance of the channel boundary to flowing water, producing swifter, shallower flows. Clearly, wood removal would not increase existing water depths along the Rio Grande RM 0-610 from existing conditions to those required for commercial shallow draft navigation.

#### *Dredging of naturally shallow stretches of the river*

MacAllister does not discuss any specifics related to dredging the Rio Grande. The amount of dredging work needed to create a 9 ft channel would likely be immense. Ancil Taylor's expert report (Taylor 2024) provides a robust estimate of the dredging requirements for development of a canalized waterway.

#### *Bank stabilization*

Bank stabilization would be one component of the sediment management and river training activities described above. The amount of bank stabilization required would be subject to the specific hydraulic and geotechnical conditions at each bank segment along the waterway. Some waterways require stabilization of the outer bank of almost every bend while others require less.

*Conduct plant species control*

Development of a shallow draft waterway along the Rio Grande would involve radical transformation of physical habitat along a major river corridor and likely would result in shifts in plant and animal species composition and distribution. It is possible that nuisance aggressive aquatic plants, particularly invasive exotic species, might be favored by the impoundments at the required locks and dams. Ecological and perhaps physical habitat model studies might be used to assess the likelihood of such an occurrence. Control programs might be needed.

*Improve existing and add additional boat ramps and access areas*

While MacAllister mentions installation of boat ramps and access points as an enhancement of navigability, boat ramps, picnic areas, camping areas and other types of river access would do nothing to add or enhance commercial navigability of the Rio Grande.

**Timmel opinion****Qualifications**

Captain John C. Timmel is a professional mariner and harbor pilot. He is an expert in commercial marine operations as well as in pleasure craft and yachting safety, standards, and practices. He has piloted vessels of a wide range of sizes and purposes in a wide variety of waterways.

However, Captain Timmel is not a hydraulic engineer. He does not have experience or education in river engineering, movable bed hydraulics or sediment management. He would not be qualified to opine on the feasibility of improvements to the Rio Grande.

## Hydraulic improvements

Captain Timmel does not propose specific hydraulic improvements or modifications to develop the Rio Grande for navigation. He instead notes that dredging of the Alafia River, Florida, rendered that channel useful for navigation:

....the Alafia River in Tampa Bay is most pertinent to this case as it has some similarities to the Rio Grande in that it was originally a narrow, shallow river that in the early 1930's had a depth of six (6) to fifteen (15) feet and was unsuitable for deep draft commercial vessel traffic.<sup>19</sup> Since then, it has been dredged to successively greater widths and deeper controlling depths and, thereby, transformed into a thriving commercial channel that can accommodate vessels just as the Rio Grande could be.<sup>20</sup>

I disagree that the Alafia River navigation channel provides an example relevant to the Rio Grande. The Alafia navigation channel is a sluggish coastal stream with a drainage area of 419 square miles that formerly flowed through wetlands. Now it is almost straight, less than 4 miles long and has very mild slope with a dredged channel 200 ft wide and 34 ft deep (US Corps of Engineers 2017). In contrast, the reach of the Rio Grande in question has a drainage area of 176,333 square miles, is sinuous, 610 miles long and has a slope ranging from 0.8 to 2.6 ft/mile. The Rio Grande average flow varies widely along its length due to diversion, tributary inflows and other factors, but near the mouth is about 2,900 cfs while the Alafia mean daily flow is only 172 cfs<sup>21</sup>. The Alafia is a coastal channelized river with such low slopes that the straight, deep channel

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<sup>19</sup> Review of Previous Reports, Alafia River, Letter from the Secretary of War, War Department, Office of The Division Engineer, South Atlantic Division, August 1, 1940.

<sup>20</sup> Timmel Expert Report at 5.

<sup>21</sup> Streamstats gage page for USGS 02301718, streamstats.usgs.gov

does not require locks and dams to retain water. In fact, the channel is low enough to experience tidal fluctuations. The Rio Grande is much steeper, and dredging the existing river to deepen and straighten the channel would make flows swifter and shallower than they already are.

Timmel does not comment on the information, data, modeling and studies needed to determine the amount of dredging needed to straighten and deepen the Rio Grande as was done on the Alafia. He does not explain how the steep slope of the Rio Grande would be handled, or how much additional water would be required to provide navigable depths in the deeper, wider, straighter dredged channel. Without such information, an estimate of project costs or overall feasibility cannot be ascertained.

## Key assumptions

The following definitions promulgated by the National Academies of Science, Engineering and Medicine (2015) are relevant to this report:

- Inland waterways commercial navigation. Vessel movements for freight transport.
- Inland waterways navigation. Vessel movements for freight transport.
- Tow. A barge or group of barges (as many as 60 on the Lower Mississippi River) lashed together and propelled by a push boat (commonly called a tow boat).

A commercially viable shallow draft waterway on the Rio Grande between the mouth and Amistad Dam (RM 610) would require a minimum authorized depth of 9 ft and minimum authorized width of 250 ft. This width is conservative for a waterway channel with bends. Passage of tows through bends, especially when two-way traffic is involved, can require minimum channel widths of 300 ft to 600 ft (Petersen 1986).

Official guidance for layout and design of shallow draft waterways (waterways that are used for commercial barge traffic like the Missouri, Mississippi, Ohio, Tennessee-Tombigbee and Gulf Intracoastal Waterway) is provided by the Corps in Engineer Manual 1110-2-1611 (USACE 1980). Commercial traffic comprises one or more barges pushed by tow boats. These clusters of vessels are called tows.

Modern waterways are designed to have a minimum water depth of 9 ft, but deeper channels are desirable since it requires less energy to move barges in deeper waters. There were some older waterways with shallower depths, but I believe all of these have been deauthorized. National Academies (2015) provides a catalog of shallow draft waterways in the US.

Minimum waterway channel widths refer to the bottom width of the channel. The manual provides guidelines for one-way and two-way traffic waterways. Widths must allow for space on the sides of the barges and between up-bound and down-bound tows on two-way waterways. Additional width is required in bends and in areas where barges or moored or grouped into tows (such as up- and downstream of locks). “Operating experience has indicated that the minimum clearance required for reasonably safe navigation in straight reaches should be at least 20 feet between tows and channel limits for two-way traffic, 40 feet for one-way traffic, and at least 50 feet between tows when passing.” “Channel widths of less than 130 ft are not recommended for commercial traffic.”

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5. cbec, inc. and Shields Engineering, LLC. 2018. A comparison of flood impacts of two operational protocols for the Saluda project. cbec project 16-1019-2. Draft report submitted to Willoughby and Hoefer, PA. Columbia, SC.
6. Shields, F.D. and Stofleth, J. 2019. Assessment of Saluda Dam Operation. Columbia, South Carolina, October 1-5, 2015. Draft report submitted to Willoughby and Hoefer, PA. Columbia, SC.
7. Shields, F. D., Downs, G., Stofleth, J., Stegman, T., and Bowles, C. 2020. Feather River computer model and potential applications to critical habitat and essential fish habitat issues: an overview. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.
8. Shields, F. D., Downs, G., Stofleth, J., Stegman, T., and Bowles, C. 2020. An assessment of changes to physical habitat resulting from the 2017 spillway incident: An application of a 2D sediment transport model to characterize potential effects. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.

9. Shields, D., Stofleth, J., Downs, G., Stegman, T. and Bowles, C. 2021. A Summary of Opinions Regarding Alleged Damages to JEM Farms and Chandon Ranch Properties during the 2017 High Flow Event. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.
10. Stofleth, J., Shields, F.D., Stegman, T., Campbell, C., and Bowles, C. 2021. Summary of Opinions Regarding Hydraulic Simulation of Selected Reaches of the Feather River, the Sacramento River and adjacent bypasses, California. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.
11. Stofleth, J., Shields, F.D., Bowles, C., Stegman, T., and Larson, L. 2021. Summary of Opinions regarding development of a Computer Model of Surface Water Movements for the Tom Miller Jr. Property Yuba City, California. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.
12. Shields, F. D., Stofleth, J., Downs, G., Stegman, T., and Bowles, C. 2021. A Summary of Opinions Regarding Alleged Damages to the RD 1600 Unit 2 Levee during the 2017 High Flow Event. Prepared for California Department of Water Resources. cbec Project #: 18-1022. cbec, inc. West Sacramento, CA.
13. Shields, F. D. 2022. Assessment of Catawba-Wateree Project Operation, North and South Carolina, June 4-11, 2019. Shields Engineering, LLC, University, MS.

## Expert compensation

For this case I have been retained by ExpertConnect Litigation Support on behalf of the Office of the Attorney General of the State of Texas at the following rate:

Hourly Review Rate: \$270.00

Hourly In-Person Rate: \$380.00

Hourly Travel Rate: \$270.00

## Signature Page

*F. Douglas Shields, Jr.*

## Appendix A: Resume of F. Douglas Shields, Jr.

Douglas Shields, Jr., Ph.D., P.E., D.WRE  
 CONSULTING HYDRAULIC ENGINEER  
 SHIELDS ENGINEERING, LLC



850 INSIGHT PARK  
 UNIVERSITY, MS 38677  
[www.friendofrivers.com](http://www.friendofrivers.com)

662.380.3944  
[doug2shields@gmail.com](mailto:doug2shields@gmail.com)

Dr. Doug Shields has 47 years of experience in water resources and environmental engineering, including 12 years working for the U.S. Army Corps of Engineers (Corps) and 22 years as a Research Hydraulic Engineer at the National Sedimentation Laboratory (NSL) in Oxford, Mississippi. Dr. Shields' research focused on the response of fluvial systems to human influences and development of environmental design criteria for all types of channel stabilization and modification projects, including streambank erosion controls and management of riverine backwaters. He is a leading authority on stream and river restoration, was a founding member of the ASCE Task Committee on River Restoration, a past chair of the River Restoration committee, and a past chair of the hydraulics and waterways council of the ASCE/EWRI. He has served as an instructor for short courses sponsored by the Corps, ASCE and the State of California. Doug has authored or co-authored more than 310 technical publications and has completed consulting projects dealing with stream restoration, erosion protection of riparian cultural resources sites, streambank erosion, geomorphic assessment, sediment management, large wood design and local flooding. Doug is a certified Professional Hydrologist and is registered as a professional engineer in four states.

### Current Position

Principal and Hydraulic Engineer, Shields Engineering, LLC

Hydraulic Engineer, cbec eco engineering, West Sacramento, California (part time)

### Education

1983–87 Colorado State University; Hydraulics; Ph.D. 1987, 4.0/4.0

1975–77 Vanderbilt University; Environmental and Water Resources Engineering; M.S., 1977, 4.0/4.0

1971–75 Harding University; major in Mathematics, minor in Physics; B.S., summa cum laude,  
 1975 3.9/4.0

### Certification

Registered professional engineer in the State of Mississippi since 1981, number 08360

Registered professional engineer (P.E.) in the State of South Carolina since 2018, number 35468

Registered professional engineer(P.E.) in the State of North Carolina since 2020, number 050441

Registered professional engineer(P.E.) in the State of Georgia since 2023, number 049881

Certified professional hydrologist (surface water), American Institute of Hydrology, certification number 18-H-9001

### Membership in Professional Societies

- Fellow, American Society of Civil Engineers (ASCE)
- Fellow, Environmental and Water Resources Institute
- Diplomate, American Academy of Water Resources Engineers
- Order of the Engineer

### Career

1977–78	Instructor and Research Associate, Department of Civil Engineering, Tennessee State University, Nashville
1978–80	Hydraulic Engineer, Nashville District, U.S. Army Corps of Engineers
1980–90	Research Civil Engineer, U.S. Army Corps of Engineers Waterways Experiment Station (WES), Vicksburg, Mississippi
1986–87	Supervisory Research Civil Engineer, Acting Chief, Water Resources Engineering Group, WES, Vicksburg, Mississippi
1990–2012	Research Hydraulic Engineer, U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS), NSL, Oxford, Mississippi
1994–pres.	Adjunct Professor, Department of Civil Engineering, University of Mississippi, Oxford, Mississippi
2012–pres.	Principal, Shields Engineering, LLC, Oxford, Mississippi
2012–pres.	Hydraulic Engineer, cbec eco engineering (part time), West Sacramento, California

### Direction of Graduate Research

1997	Martin W. Doyle. Bed material size trends in incised channels. M.S. thesis, University of Mississippi.
2001	Nathalie Morin. Specific gravity of naturally occurring large woody debris in the river environment. Internship report, L'INRS-Eau, Terre et Environment (in French).
2005	John M. Stofleth. Hyporheic and total storage exchange in small sand-bed streams. M.S. thesis, University of Mississippi.
2012	Mary A. McCaskill. Bacterial and sediment transport in an artificial sand bed stream during unsteady flow. M.S. thesis, University of Mississippi.

### Awards

2008	Diplomate, American Academy of Water Resources Engineers
1999	Bronze Award, U.S. Environmental Protection Agency Office of Water
1997	ASCE Hydraulic Engineering Achievement Award, Mississippi Section
1984	ASCE Zone II Young Government Civil Engineer of the Year
1983–84	U.S. Army Corps of Engineers Civil Works Fellowship
1975–76	Energy Research and Development Agency trainee fellowship, Vanderbilt University

### Offices and Committee Assignments Held in Professional and Honorary Societies

1986–90	Control member of ASCE Task Committee on Aquatic Habitat and Sedimentation
1991–95	Corresponding member of ASCE Task Committee to update Sedimentation Engineering Manual and Report on Engineering Practice No. 54
1994–2005	Board of Governors, Order of the Engineer, University of Mississippi, Link No. 149
1996–07	Control member of ASCE Task Committee on Sedimentation Engineering for River Restoration
2007–09	Chair of ASCE Hydraulics and Waterways Committee
2012–13	Vice Chair, ASCE River Restoration Technical Committee
2013	Chair, ASCE River Restoration Technical Committee
2016	Chair, ASCE Task Committee on Representation of Vegetation in Two-Dimensional Hydrodynamic Models

### Selected Invitations

- Invited to present, “Evaluating Impacts of Channel Stabilization Structures on Riverine Habitats,” to the meeting of the Environmental Advisory Board of the Chief of Engineers, U.S. Army Corps of Engineers, Denver, Colorado, October 7, 1987.
- Invited by the Southern Division, American Fisheries Society, to co-author chapter, “Dikes and Levees,” for book, *Impacts on Warmwater Streams: Guidelines for Evaluation*, with C. H. Pennington, 1989.
- Invited to present, “Engineering Constraints on Riverine Habitat Restoration,” Missouri River Mitigation Workshop, Desoto National Wildlife Refuge, Iowa, June 27–28, 1990, U.S. Fish and Wildlife Service. Interagency workshop laid foundation for major mitigation project.
- Invited by the Korean Institute of Construction Technology to visit South Korea and present seminar, “Instream Flow Methods to Meet Recreational and Aesthetic Objectives,” and discuss current research activities. In concert with this invitation, also invited to deliver keynote address, “Rehabilitation of Watersheds with Incising Channels in Mississippi, USA,” to the annual meeting of the Korean Society of Civil Engineers, October 17–23, 1994.
- Invited by USDA Natural Resources Conservation Service (NRCS) to chair interagency team of experts requested to visit North River Watershed in Missouri and to provide transfer of technology developed by the Demonstration Erosion Control Program to landowners, U.S. Fish and Wildlife Service, and state agencies, October 23–25, 1995.
- Invited by a consortium of the Environmental Defense Fund, the Bay Institute, and Philip Williams and Associates, all of San Francisco, to serve on an expert review panel for a study preparing a framework for restoration of the San Francisco Bay–Delta River ecosystem, October 30, 1995—October 1997.
- Invited by Ontario Ministry of Natural Resources (Canada) to participate in the Temperate Wetland Restoration Workshop in Barrie, Ontario, and present, “Physical Perturbations on Temperate Riverine Wetlands.” The workshop was sponsored by Environment Canada, Ontario Ministry of Natural Resources, Ontario Ministry of Environment and Energy, Trent University, and Ducks Unlimited Canada, November 27–December 1, 1995.
- By invitation of the USDA NRCS International Conservation Division, worked as part of an interdisciplinary, interagency team to review forested riparian buffer strip research and management practices in Taiwan. The assignment included presenting a lecture on the state of science and ongoing research, touring field research sites in Taiwan with Taiwanese scientists and officials, and co-authoring a memorandum detailing recommendations, June 14–21, 1996.
- Invited by the Comité Intergubernamental de la Hidrovia Parana-Paraguay (CIH), Buenos Aires, Argentina, to serve on a five-person expert panel to review hydrologic studies conducted to assess technical and economic feasibility and environmental impacts of construction of the Hidrovia project—a collaborative effort among five South American countries to improve navigation conditions along 3442 kilometers of river using dredging and other channel modifications. The project could impact the Patanal, the world’s largest freshwater wetland. Thanks to recommendations of the incumbent and other panelists, governments of the countries involved initiated reconsideration of the project’s impacts, November 19–21, 1996.
- Invited to serve as a convener for five technical sessions on stream habitat restoration for the XXVII Congress of the International Association of Hydraulic Research, August 10–15, 1997.
- Invited to present keynote address in May 1998 at the International Symposium on River Restoration, Technology Research Center for Riverfront Development, Tokyo, Japan, July 15, 1997.

- Invited to serve as examiner for Ph.D. dissertation, “On the role of woody vegetation in riverbank stability,” by Bruce Abernethy. Dissertation submitted to Department of Civil Engineering, Monash University, Clayton, Victoria, Australia, March 1999.
- Invited to present lecture, “Ecological Engineering in Research and Practice,” to annual meeting of the American Ecological Engineering Society, University of Georgia, Athens, May 1, 2001.
- Invited to make presentation “Interactions of Riparian Zones with Aquatic Restoration,” to American Water Resources Association Summer Specialty Conference on Riparian Ecosystems, June 2004.
- Invited to make presentation on river restoration monitoring to meeting of National River Restoration Synthesis Project, Santa Barbara, California, August 20, 2005 (declined).
- Invited to join the National Center for Earth Dynamics (NCED) Stream Restoration Partners Group, University of Minnesota, February 9, 2005. Later invited to participate in expert panel workshop on training for stream restoration practitioners sponsored by the NCED, April 2–4, 2006.
- Invited to chair session and make presentation on large wood in streams at the Sixth Annual Stream Restoration Design Symposium, Skamania Lodge, Washington, February 7, 2007.
- Invited to make presentation, “Stream Restoration Design,” and serve on panel for discussion of new ASCE Manual of Practice: Manual 110 Sedimentation Engineering, at the Environmental and Water Resources Institute World Water Congress 2007, Tampa, Florida, May 17, 2007.
- Invited to make presentation, “Role of Vegetation in Bank Stability & Revetments” and participate in a panel discussion, “Applying the Engineering and Science to Solutions,” as part of the Levee Vegetation Symposium organized by Sacramento Area Flood Control Agency. This symposium was sponsored by the Corps, State of California Reclamation Board, California Department of Water Resources, and the Sacramento Area Flood Control Agency to explore science, real-world experience, challenges, and policy solutions related to levee vegetation. The Corps proposed tighter vegetation regulations for earthen levees in the wake of the Katrina disaster, triggering a crisis for local sponsors of levee projects. Registration numbers revealed over 511 people from 21 states nationwide registered for the symposium, representing over 151 agencies from federal, state, and local flood management, resource agencies, academic institutions, and consulting engineering and environmental firms. August 28–29, 2007.
- Invited by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, to serve on an expert panel on setting up a process for reviewing proposed stream habitat restoration projects, December 11–12, 2007.
- Invited by National Marine Fisheries Service to serve as expert reviewer for River Restoration Analysis Tool, <http://www.restorationreview.com/>, 2010.
- Interviewed by the U.S. Government Accountability Office to provide input to a comprehensive review of the hydrologic and environmental effects of river training structures on the Mississippi River, <http://www.gao.gov/products/GAO-12-41>, 2011.
- Invited by the Bureau of Reclamation to participate in a technical workshop on large wood applications and research needs in river restoration, 2012.
- Invited to present a series of lectures on river restoration research and challenges, Bureau of Reclamation, Denver, Colorado, 2014.

### Short Courses and Webinars

- 1982-1993. Regular lecturer on environmental design considerations for the following annual short courses conducted at the U.S. Army Engineer Waterways Experiment Station: Streambank Protection, Hydraulic Design of Flood Control Channels, Environmental Aspects of Local Flood Protection Projects, Hydraulic Design for Project Engineers and Planners
2014. Rapid assessment of channel stability at highway stream crossings. For California Department of Transportation, Roseville, CA.
- 2014 - 2020. Stream Restoration: What Works and What Doesn't Work, ASCE online webinar.
- 2015 and 2016. Planning and Design for Stream Rehabilitation with Large Wood, ASCE online webinar.
2015. Restoring Rivers with Wood. Short course for Yurok tribe. Weaverville, CA.
2015. Planning and Design of Rivers Using Large Wood, University of Engineering, Lima, Peru.
- 2017 and 2018. Designing Channels for Stream Restoration: Alluvial Channel Design, ASCE Webinar.
- 2017 and 2018. Designing Channels for Stream Restoration: Threshold Channel Design, ASCE Webinar.
2017. Reach Scale Design for River Rehabilitation with Large Wood, ASCE Webinar.
- 2017 and 2020. Sediment Characteristics, Sources, and Movement, ASCE Webinar.
2018. River Restoration with Large Wood: Detailed Design and Construction, ASCE Webinar.
2020. Beaver Dam Analogue Design: Using the Tool, ASCE Webinar.
- 2020-21. Rapid Geomorphic Assessment. (online short course) California State Water Resources Board.
- 2020-21. Sediment and Erosion Control 101. (online short course) California State Water Resources Control Board.

## Stream and River Restoration Experience

1991–93	Responsible for site selection, real estate, planning, design, and direction of construction for three stream restoration projects in incised channels in northwestern Mississippi. Treatments included instream weirs, riprap toe protection, spur (wing) dikes, and willow planting on a total 10,000 linear feet of channels. Monitoring continued for up to 11 years, including collections from degraded and pristine reference sites. All research findings have been published in refereed literature.
1998–2006	Responsible for site selection, real estate, planning, design, and direction of construction for a 6000-foot stream restoration project in central Mississippi. Channel treatments were limited to plant materials (large wood, willow cuttings, switchgrass plantings). Monitoring continued through 2004. Research was interdisciplinary and involved scientists from several universities and government agencies. Research findings have been published in refereed literature.
2000–01	Identified environmental enhancement opportunities for an urban river corridor, for the Menominee River Watershed Assessment, Milwaukee, Wisconsin. Subconsultant to Interfluve, Inc.
2001–03	Developed software to advise users on selecting appropriate environmentally sensitive channel and bank protection measures for a given site. Subconsultant to Salix Applied Earthcare on contract with National Cooperative Highway Research Program.
2004–05	Developed channel stabilization plan for Kinishba Wash at Kinishba Ruins, Arizona. Subconsultant to Nickens & Associates.
2006	Assessed performance of biotechnical stabilization of a Hasotino cultural resources site, Snake River, Washington. Subconsultant to Nickens & Associates.
2006	Designed Miller Creek restoration project, Mobile, Alabama. Subconsultant to Volkert and Associates. Project intended to rehabilitate stream from damages produced by illegal modifications, and featured extensive use of large wood.
2007–08	Performed geomorphic analysis to support planning for Amite River restoration project, Louisiana. Subconsultant to Taylor Engineering. Lead author on literature review and field assessment of geomorphic status of major river system.
2008–2017	Served on expert review panel for the Sacramento Area Flood Control Agency and California Levee Vegetation Science Team. Provided

technical review for comprehensive research program to assess effects of trees and tree removal on earthen flood control levees.

- 2009                      Provided expert review of Platte River Recovery Implementation Program Monitoring Protocol for Channel Geomorphology and In-Channel Vegetation, Headwaters Corporation, Kearney, Nebraska.
  
- 2011–12                As subconsultant to cbec eco engineering, West Sacramento, California, analyzed Swift Slough restoration feasibility and assisted team in developing design alternatives to enhance the hydrologic connectivity of Swift Slough, a major backwater on the Apalachicola River, Florida.
  
- 2012–15                As subconsultant to ICF International, helped prepare national guidelines for placement of large wood in streams. Team project resulting in major federal interagency handbook.
  
- 2012–16                As member of Russian River Independent Science Review Panel (California Land Stewardship Institute), holistically assessed water use and ecological impacts in the Russian River watershed of northern California.
  
- 2013–2015            As subconsultant to Ayres and Associates, Fort Collins, Colorado, evaluated and assessed environmentally sensitive stream bank protection measures. Project funded by Transportation Research Board, National Cooperative Highway Research Program (NCHRP Project 24-39). Worked with interdisciplinary team to develop quantitative design guidance for biotechnical bank protection measures.
  
- 2012–pres.            As a part-time hydraulic engineer for cbec eco engineering, West Sacramento, provide senior-level review and advisory services on the Southport Early Implementation Project levee setback, develop guidance for Rapid Stream Stability Assessment for use by Caltrans, provide technical support for the California Department of Water Resources with regard to levee vegetation policy, effects of riparian vegetation on flow resistance, and matters under regulatory review or in litigation. Serve as short course instructor and conduct other projects.

### Advisory Activities

Between 1985 and 1990, served as in-house expert for U.S. Army Corps of Engineers field offices for environmental issues related to stream channel modifications, dredging, and dredged material disposal (nationwide). Consultations (three to six per year) sometimes were limited to telephone conversations, but usually involved face-to-face meetings, seminar presentations, site visits, literature review, and preparation of letter reports. Typical examples include preparation of a monitoring plan for sediment deposition in cutoff meander bends along the Tombigbee River portion of the Tennessee-Tombigbee Waterway (Mobile District, 1985); field consultation with the New England Division (1986) regarding impacts of gravel mining in Naugatuck River, Connecticut; seminar for interagency group at Memphis District (1987) regarding application of stream obstruction removal guidelines to the Cache River, Arkansas; and field and office consultations regarding habitat restoration within Anacostia River Basin, Maryland (Baltimore District, 1990).

Similar short-term consultations were also provided to personnel of other government agencies one to three times per year. Examples include work with the George D. Aiken Resource, Conservation, and Development Area of Randolph, Vermont, regarding engineering design criteria for aquatic habitat improvement structures for the Ottauquechee River, Vermont (1984); the Minnesota Department of Natural Resources, regarding selective removal of large woody debris from streams for flood stage reduction (1984); U.S. Fish and Wildlife Service, Bloomington, Indiana, regarding incorporation of artificial wetlands in an enlarged channel (1987); and staff of the New Jersey Legislature regarding construction of dredged material containment islands (1988).

Participated in periodic coordination meetings for the Demonstration Erosion Control Project with technical experts from the Corps, NRCS, the U.S. Geological Survey (USGS), and universities. Presented stream restoration research plans and results. Contributed to discussions regarding morphologic evolution of incised channels and attendant impacts on habitat and downstream sediment yield. Meetings included stream restoration sites (October 28–29, 1991); Greenwood, Mississippi (August 20, 1992); Hotophia Creek restoration site (January 14, 1992); WES Hydraulics Laboratory (September 8, 1992, January 12–13, 1993, February 25, 1993); National Sedimentation Laboratory (October 21, 1993, April 22, 1993).

Organized briefings and field trips for interagency groups and foreign visitors to incumbent's stream restoration and stabilization research sites for technology transfer. Audiences included fellows of the Food and Agriculture Organization of the United Nations (1991); 12 engineers and scientists from the Corps, NRCS, U.S. Fish and Wildlife Service, ARS, and the State of Mississippi (1992); eight engineers and scientists from the Corps Mobile District (1993); two engineers from the Korean Institute of Construction Technology (1993); five engineers and biologists from Baltimore Corps District working on Passaic River, New Jersey, flood control project (1994); the Options Appraisal Manager, National Centre for Risk Analysis and Options Appraisal, the Environment Agency, England and Wales (1997); and six engineers and scientists from the Missouri Department of Conservation (1999).

Provided consultation and literature to Executive Director, Golden State Wildlife Federation, Sacramento, California, regarding effects of levees on riverine and floodplain ecosystems (October 21, 1993).

At the request of the St. Louis District of the Corps, worked as part of an interdisciplinary team to provide recommendations regarding aquatic and wetland habitat restoration opportunities associated with repair of levees damaged by the 1993 Midwest flood. Concepts were used by Corps personnel in a report to district managers (November 30–December 2, 1993).

Provided technology transfer to Stream Program Coordinator, Missouri Department of Conservation, including through in-depth discussions, inspection of field research sites, and provision of literature to support programs demonstrating stream rehabilitation technology to riparian landowners (April 4–5, 1995, January 21–23, 2003).

Provided field consultation to hydraulic engineer of the Corps' Mobile District and research hydraulic engineer of the WES regarding stream restoration design for a 2.5-mile-long, \$1 million project on Twentymile Creek, Mississippi (May 22, 1995). Summarized observations in a letter report. Provided additional consultation to hydraulic engineers and biologists of the Mobile District regarding planning and design of restoration structures and plantings for this project (August 31, 1995, May 14, 1996).

Informed the Chief of River Engineering Division, Coastal and Hydraulic Engineering Laboratory, WES, of the status and probable environmental impacts of Hidrovia Parana-Paraguay Waterway Project (September 3, 1997).

At the invitation of the U.S. Forest Service, provided on-site consultation and a letter report regarding stabilization and restoration of stream corridors threatened with incision in the Homochitto National Forest (November 2001).

At the invitation of the Corps, provided on-site advice and consultation regarding planning and designing restoration of the Salmon River near Challis, Idaho (July 30–August 1, 2002).

Assisted in hosting delegations from Korean Institute of Construction Technology and National Center for Computational Hydroscience and Engineering, University of Mississippi, for briefings on river restoration research and tours of the NSL (May 29, 2002, October 15, 2002).

At the invitation of the Michigan Sea Grant Program, delivered a lecture and participated in a panel discussion for a workshop on environmentally sensitive streambank and shoreline erosion control (~100 participants) (October 29, 2003).

Provided invited review of research plans for Center for Bottomland Hardwoods Research, Southern Research Station, U.S. Forest Service (May 26, 2004).

Organized workshop on stream restoration research for 25 participants from three states (October 24–25, 2006). Eight NSL scientists gave presentations and toured restoration research field sites.

Participated in National Center for Earth Dynamics Stream Restoration Partners Group, University of Minnesota, panel and workshop on stream restoration research (2005). Trained stream restoration practitioners (2006).

Presented and participated in panel discussion, Levee Vegetation Symposium, Sacramento, California (500 participants) (August 28–29, 2007).

Served as reviewer for North Carolina Water Resources Research Institute, Environmental Fluid Mechanics, Journal of Environmental Quality, AI Applications in Natural Resource Management, Environmental Management, Soil Science Society of America Journal, Journal of Environmental Engineering, Transactions of the American Society of Agricultural Engineers, River Research and Applications, Geomorphology, Journal of Hydraulic Engineering, North American Journal of Fisheries Management, Fisheries, Aquatic Conservation, Water Resources Bulletin, Journal of the American Water Resources Association, and Journal of Hydrologic Engineering, and Journal of Hydraulic Research, Journal of Flood Risk Management. Served on editorial board of Environmental Management (1999-2003).

## Special Assignments

- 1982–87 Participated in Environmental Manual Advisory Group (Corps WES). Responsible for producing a series of manuals to incorporate environmental criteria into standard procedures for design, operation, and maintenance of reservoir, waterway, and flood control channel projects.
- 1985 Served as member of Environmental Water Quality and Operational Studies overview briefing team (Corps). Team visited Corps field offices and presented seminars summarizing findings of 5-year, \$30 million research program. These presentations laid groundwork for ensuing transfer of technology to field offices.
- 1982–93 Regularly lectured on environmental design considerations for the following annual short courses conducted at the WES:
- Streambank Protection
  - Hydraulic Design of Flood Control Channels
  - Environmental Aspects of Local Flood Protection Projects
  - Hydraulic Design for Project Engineers and Planners
- 1996 Chaired meeting involving scientists from University of Middlesex, U.K., who were engaged in studying engineering uses of willows, as well as USDA NRCS plant materials center personnel, active and retired NSL scientists, and visiting scientists. Meeting included briefing on findings of current and recently completed research and visits to field sites. Data and findings were used by visitors in their study.
- 1996 Co-hosted tour of Demonstration Erosion Control Project watersheds for a group of NRCS state conservationists from 10 southeastern states, Soil and Water Conservation Commissioners, and other officials.
- 1997 Served as technical program co-chair and co-editor of proceedings of the international conference, “Management of Landscapes Disturbed by Channel Incision”. Conference drew 250 participants from 25 states and 26 foreign countries.
- 1999–2004 Served as director of the Little Topashaw Creek Stream Corridor Rehabilitation Project, coordinating work among NSL scientists, cooperators, and landowners. This project provided a setting for interdisciplinary research involving three universities and three federal agencies in areas relating to erosion control, ecosystem rehabilitation, and water quality in an agricultural watershed. To date, this project has provided a basis for 18 proceedings papers, three poster presentations, two technical sessions at a national conference, and 11 refereed journal papers. The project has hosted field tours for the Corps’ Advanced Streambank Protection short course (twice), scientists and engineers from USDA NRCS, Mississippi offices, students and professor from Oklahoma State University, and eight scientists from Northeast Forest University, China. Developed website to facilitate technology transfer. (<http://ars.usda.gov/Research/docs.htm?docid=5526>)
- 1999 Directed the technical watershed tour for about 35 participants in the US–China Bilateral Workshop: Sediment Management in Agricultural Watersheds.
- 2004 Directed the technical watershed tour for the Third International Conference on Gully Erosion (GEC III).
- 2004–10 Served as coordinator of Coldwater River Watershed Rehabilitation project. This project is an investigation of riverine backwater management to yield ecological services in the agricultural landscape. Developed website to transfer initial findings. (<http://www.ars.usda.gov/Research/docs.htm?docid=12773>)

2007–08 Served as the technical publications co-chair for the conference, “The National Sedimentation Laboratory: 50 Years of Soil and Water Research in a Changing Agricultural Environment.”